Examples of Agency User Needs for the Workshop on Land Use/Land Cover Change Scenarios and Projections for the United States - June 25-27, 2014

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Julia Gamas, U.S. EPA, Office of Air Quality Planning and Standards, Air Economics Group, Scenario Needs in Air Quality Analyses

To inform our analyses of the impacts of air quality regulations we must project emissions and air quality into the future. For this reason we would like to know where future emissions will be located and what the level of economic activity will be in those locations. For example:

- Where will the population be located? Will there be more growth in urban areas? Or will the population move out to current suburban and ex-urban areas?
- Where will major industrial and commercial sources of air emissions be located? What will their growth patterns in terms of location and size be?
- Will climate change have impacts on the future location of people and their local economies?

Current IPCC scenarios, for example, are informative but are too broad in scale to inform more localized impacts within the U.S. And while climate impacts are envisioned out to 100 years into the future, air quality impacts are typically studied out 20 years into the future. Other kinds of scenarios seem to be dictated by the model and the parameter that the model uses but don't tell us anything about potential unforeseen paths that society and technology might take. This is because model parameters are typically estimated on historic data, but the past may not be the best predictor of the future.

Different pollutants have different impacts in terms of their temporal and geographic scale. Once a pollutant has been emitted, different physical processes and chemical reactions will determine concentrations as well as how the population and environment will be exposed. Impacts are relevant at different geographic scales (local, regional, national, and global) but also temporal scales (for example, air quality impacts are shorter term than anticipated climate changes). Some pollutants have a more localized impact depending upon the emission source (volatile organic compounds or VOC and nitrogen oxides or NO_x, and toxics such as asbestos), some a regional impact (such as sulfur dioxide or SO_2 when

emitted from tall power plant stacks), and some a more global impact (toxics such as lead and mercury, and greenhouse gases). Furthermore, some pollutants (Black Carbon or BC) can have both climate forcing (affecting climate) and human health impacts. Additionally, climate forcing can be either positive (carbon dioxide or CO_2) or negative (SO_2)[1].

Because air quality and the human systems (economic, political, and social) that affect it are complex, it is not possible to predict the future with precision. There are many driving forces of air quality that interact with one another. Important drivers include: societal attitudes with respect to factors such as the environment, consumption, mobility, and conservation and the direction and pace technological change, energy (extraction, conversion, distribution and storage, efficiency, international energy trends); development patterns (type of human settlements, vehicle-miles travelled); the path and direction of the economy; policies (energy efficiency, energy security, direction of research and development); the strength of the climate change signal (temperature and precipitation, damages from storms and flooding, interactions between climate change and air quality); emissions reductions technologies; other technological developments; and finally, environmental indicators other than climate change (ecosystem health, persistence of pollutants, water resource quantity and quality).

Regardless of how an air quality scenario is constructed, it must be supported by plausible assumptions. LULCC could supply plausible assumptions about land use for our scenarios. The LULCC workshop would also provide a group of professionals with expertise in different areas to draw on when constructing our scenarios. Finally, more than a specific set of scenarios, the LULCC workshop can provide a better understanding of the drivers behind land use and the potential outcome of interactions with air quality drivers.

[1] Positive forcing means the pollutant warms the Earth. Negative forcing means the pollutant cools the Earth. (See: http://www.ncdc.noaa.gov/paleo/globalwarming/gw-forcing.html). Accessed October 2012.

Matt Nicholson, U.S. EPA, Region 3 (MidAtlantic), Landscape Ecologist

Introduction

- Landscape ecologist w/ Midatlantic region of EPA
- Role is to id relevant science and help programs and external partners apply it
- Do not develop scenarios but try to understand how we can use these scenarios in decision making.

In answering the questions posed to the panelists I received feedback from colleagues I work with

- in programs in the MidAtlantic,
- in other regional offices and
- in national program offices.

Why are you interested in using LULCC scenarios and projections?

- I think there has been an evolution in how we perceive landscape change and how we use that information as an agency.
- As I need to often stress EPA is not a land management agency.
- It has become more evident to decision makers that landscape change impacts all of those things we do worry about as an agency.
- Example: 2010 regional prioritization exercise. Over a hundred metrics to get at emerging challenges we need to consider. Land change metrics rated among the top.

Why are you interested in using LULCC scenarios?

Those folks I talked with primarily see LULCC scenarios as an input in models of impacts to natural resources and human health.

Another use for land change scenarios is to provide context to decisions.

Have you used LULC scenarios and projections in the past or intend to use in the future?

1. For the prioritization exercise I mentioned.
   - Used Landuse projections developed through the MidAtlantic Integrated Assessment completed in 2001 and projecting approx. 40 years into future. 30 meter resolution and primarily an urban growth analysis.
2. Fine scale (10m) projections of mountain top mining development in the coal region of southern WV for better understanding cumulative impacts.
3. We have access to the great work by Peter Claggett at the Chesapeake Bay Program
   - 30 meter resolution and has primarily been an urban growth change model. Besides the Chesapeake Bay Program, this is being used by communities developing land protection strategies to get at landscape vulnerability.
4. Finally working with Peter Claggett and a group of researchers at UMD to use coarse scale econometric based projections of land change as an input to the Chesapeake land change model.

We hope to use the output to

- explore resource impacts to air, water, human health and
- working with county government to explore how this information could be used in their planning efforts.

I'm excited that this allows for exploring how economic and policy drivers of change might impact future landscape change.

Challenge working through projections with some decision makers:

"That is not going to happen because it's my job to keep that from happening."

What temporal and spatial scales are of most importance to you.

Temporal scale.

- long term 50 – 100 year projections are important
- most land use decisions are made in 5 10 year increments so decadal scale is important.

Spatial scale.

- 10-30m resolution would be helpful as input.
- Critical spatial characteristic in our management units the projections are reasonably accurate.
  - Right now the reporting unit size for watersheds is a 12 digit hydrologic unit (ca. 40^2 mi miles)
  - Moving toward the catchment level of analysis (ca. 1^2 mi)

    _____
  - ∴ We would hope that projections of landscape change would be accurate at about a square mile

What are the most important Drivers?

Economics, Policies, Transportation networks and how those affect use such as resource extraction, climate feedbacks.

What is currently available that meets your needs?

- Use of projection has been largely reacting to problems. No survey of existing products.
- Of the models I mentioned.
  - none cover the entire MidAtlantic and all have different assumptions and are based on different approaches to projection. So, separately or together they do not meet our regional needs.
  - ICLUS urban projections are being used in watershed planning and in healthy watershed program. The later is used in tandem with climate projections to understand vulnerability.

What would you like to have available as components of LULC scenarios?

- Scenarios ideally would be linked to global climate scenarios, and demographic projections

- Would be both long term 50+ years and decadal
- Would project change in all types of land use (forest to mining, ag to forest) in addition to urban growth and intensification.
- Would allow the end user to explore effects of new policies or regulations
- Would be fine scale enough that they reasonable predict impacts to landscape structure as well as composition

WORKSHOP OUTCOMES

Ultimately a nationally consistent product that could be used as is or could be refined based on consistent and mutually acceptable approaches.

A better understanding of scenario accuracy and how error might impact interpretation and use in subsequent modeling.

The best outcome

Someone like me using the information to inform on the ground decisions

The worst outcome

Someone like me misusing the information!

∴ How any new land change projection product is rolled out will be critical to its success.

Linda Langner, US Forest Service, National Program Lead for Resources Planning Act (RPA) Assessment

- Why are you interested in using LULCC scenarios and projections (e.g. to support specific decisions, as input to analyses on resource effects, etc.)?

The decadal RPA Assessment evaluates future conditions and trends of renewable natural resources on all forest and rangelands of the United States. A set of common assumptions and projections are developed to underpin the various resource analyses – including population, economic growth, land use change, and climate change.

We would like to use multi-agency national scenarios and projections to:

1) *Provide an anchor for scenarios for the 2020 RPA Assessment, including scenarios influencing land use change, socioeconomic change, and climate change;*
2) *Evaluate historical U.S. data as basis for land use projections;*
3) *Link to land cover projections and relationship between use and cover to enhance ecological analyses; and*
4) *Incorporate climate change into land use projections to account for feedback effects over the projection period.*

- Have you used LULCC scenarios and projections in the past, and/or intend to use them in the future to support these needs?
    - If yes, briefly describe source, temporal and spatial scale.

The 2010 RPA Assessment assumptions and scenarios were linked to the IPCC's SRES for population and economic assumptions. However, our land use projections were not linked to any SRES modeling results. However, the population and income projections that are important variables in the land use projection model are linked to SRES, so there is indirect tie to those scenarios. Land use at the county scale was projected for 5 major land use classes (nonfederal only): urban and developed, forestland, rangeland, cropland, and pastureland as defined by the National Resource Inventory (NRI) data. The RPA land use projections are used to define future forest area in the United States at the county scale. The land use projections act as a bridge between many of the resource analyses that do not include socioeconomic effects directly in the model but do responds to land use change. For example, forest land area affects projections of forest carbon and wildlife diversity.

- What temporal and spatial scales are of most importance/relevance to you?

The RPA Assessment has traditionally done projections for 50 years; the spatial scale has primarily been at the county level to best match with data for socioeconomic variables. However, we are also looking at using equal-area grids to account for variation in county size in some analyses (e.g. distribution of T&E species) that might have implications for LULCC analyses.

- What do you think are the most important drivers of LULCC to consider?

Population change, economic growth patterns, economic returns to land use, technological and policy change, natural disturbances, climate feedbacks with land cover and land use.

- What is currently available that meets your needs?

We are just beginning to evaluate what is available for 2020 RPA scenarios – we are looking to AR5 results for global context. We will continue to use NLCD for landscape pattern analysis, but are interested in options for land use data besides the NRI.

- What would you like to have available as components of LULCC scenarios and projections?

LULCC scenarios: nest within integrated scenarios that include demographic, economic, technology, institutional, and policy change and climate. Linkages to global results would be desirable.

LULCC projections: at minimum, national level projections by major land use/cover classes that include quantitative linkages to other variables that can then be linked to more spatially disaggregated analysis. Better would be subnational projections of land use and cover that can then be further refined for sector-specific analyses.

- What are the most important resultant output variables for your uses?

Scenarios that include quantitative variables to drive LULCC projections, including the list of variables mentioned previously.
Scenarios that include qualitative or quantitative variables to inform sector-specific analyses, e.g. agricultural policies that influence the competing returns between agricultural and forest land.

- What specific workshop outcome would best support your user needs?

Provide a path forward from initial LULCC scenario development to completion.

Terry Sohl, Research Physical Scientist, U.S. Geological Survey (EROS), Project lead, USGS EROS Land-cover Modeling

- Why are you interested in using LULCC scenarios and projections (e.g. to support specific decisions, as input to analyses on resource effects, etc.)?

My perspectives come as a producer of LULCC projections who works directly with multiple users. We recently completed scenario-based LULCC projections for the conterminous U.S. in support of the LandCarbon project, and are also producing "backcast" LULCC (historical backcasts to the 1930s) in support of multiple hydrological applications. We are also working with Audubon to investigate potential linkages between our LULCC modeling activities and species distribution modeling.

As a LULCC modeler working with carbon, climate, biodiversity, and hydrologic applications, we necessarily have to wear many hats. Flexibility is a key. We need a modeling structure that can assess all components of the landscape, including anthropogenic (land-use) change, and "natural" change (vegetation succession, fire, climate-induced vegetation shifts, etc.), at different spatial, thematic, and temporal resolutions. Our focus is to continue work on a flexible, powerful, integrated LULCC modelling tool that can support a variety of ecological applications.

- Have you used LULCC scenarios and projections in the past, and/or intend to use them in the future to support these needs?
    - If yes, briefly describe source, temporal and spatial scale.

We have developed LULCC scenarios and projections to support multiple applications, as noted above. We will continue to do so in the future. Our past work has focused on regional- to national-scale LULCC projections, with a 250-m spatial resolution, and a thematic resolution comparable to the NLCD. As our collaborators increase, our immediate need is to increase the flexibility of our modelling tool, to support a variety of spatial, temporal, and thematic resolutions.

- What temporal and spatial scales are of most importance/relevance to you?

It's variable. Working with multiple users of LULCC projections, it's obvious there's no "one-size-fits-all" answer to this question. We've primarily produced relatively long-term (50-100 year) projections at a 250-m spatial resolution. Many applications have used our projections, as alternatives are typically not readily available. However, there's little doubt that many users would prefer data with different temporal, spatial, and thematic characteristics. I believe it's important to compile aggregate user needs to frame the potential scope for needed LULCC scenarios and projections. However, it's not a question of what's the "right" temporal and spatial scale for scenarios and LULCC projections; it's a question of how we can produce flexible modeling frameworks to satisfy the needs of a very diverse user community.

- What do you think are the most important drivers of LULCC to consider?

Again, it's specific to a given application. Climate is obviously a hot-button driver that many applications are currently considering as a "natural" driver of LULCC. Economic conditions, policy, and technology developments are anthropogenic drivers. As a producer of LULCC projections, the challenge is to have the ability to model natural and anthropogenic drivers of LULC change and the feedbacks between them, at multiple scales.

- What is currently available that meets your needs?

For a user of LULCC scenarios and projections, most of the readily available data are at intermediate to coarse scales (both spatial and thematic). County-based data from the RPA (Wear et al.), the Radeloff et al. data for the conterminous U.S., our FORE-SCE projections for the conterminous U.S….all provide broad regional- to national-scale coverage for the U.S. Integrated assessment models associated with IPCC activities (IMAGE, GCAM, etc.) provide national- to global-scale coverage. However, most of these are either very coarse spatially or thematically. Thematic content and spatial resolution of these data sets likely do not meet the needs of many users. Perhaps even more important than resolution, however, is that these projections provide a limited suite of canned scenarios. While a small set of scenarios can help bound uncertainty in future landscape conditions, they may not enable a user to explore the unique land use or land management options specific to their application.

- What would you like to have available as components of LULCC scenarios and projections?

Flexibility. LULC modeling is a different animal than something like NLCD or any other remote-sensing based mapping of land cover. We're not mapping "truth"…we're providing scenario-based projections that enable a user to explore "what-if" types of questions, unique to their specific application. "Canned" scenarios and sets of projections may not meet the needs of many users. Instead of serving as a provider of scenarios and LULC projections, it may be more valuable to provide tools that allow users to develop their own, tailored scenarios and projections.

- What are the most important resultant output variables for your uses?

Again it's variable depending upon the application, but clearly there's a need to go beyond what remote-sensing based products provide (land cover), and provide both land use and land cover information. Both quantity and location of LULC data are usually required, limiting the utility of non-spatial modeling approaches. Many models simply provide net change in LULC classes between two dates; however, gross change is important consideration for applications dealing with biogeochemistry and carbon, and other ecological applications.

- What specific workshop outcome would best support your user needs?

I do believe the ability to downscale and use globally recognized scenarios such as the IPCC SRES or RCPs is an important goal. Downscaling assumptions and characteristics from those frameworks and producing spatially explicit projections allows federal agencies to assess the impacts of LULC and climate change under a common suite of well-recognized assumptions. It allows cross-comparison and integration between applications.

However, as noted above, I think it's also important to recognize that a common suite of scenarios/projections doesn't meet the need of many users. Movement is also needed towards tools that enable users to develop their own set of scenarios and projections.